AD-A096 243 RAND CORP SANTA MONICA CA F/G 5/10

PLANNING DURING MAP LEARNING: THE GLOBAL STRATEGIES OF HIGH AND--ETC(U)

DEC 80 C STASZ N00014-78-C-0042

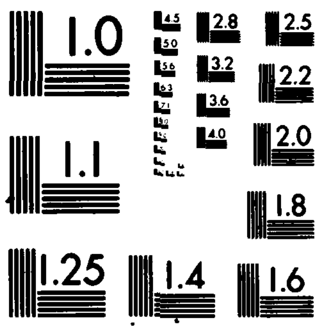
UNCLASSIFIED RAND/N-1594-ONR NL

END

DATE FILMED

4

DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

A RAND NOTE

LEVEL II

PLANNING DURING MAP LEARNING: THE GLOBAL STRATEGIES OF HIGH AND LOW VISUAL-SPATIAL INDIVIDUALS

Cathleen Stasz

December 1980

N-1594-ONR

Prepared For

The Office of Naval Research

This research was sponsored by the Personnel and Training Research Programs, Psychological Sciences Division, Office of Naval Research, under Contract No. N00014-78-C-0042. Contract Authority Identification Number NR 157-410.

Published by The Rand Corporation

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

14 RAND/ **REPORT DOCUMENTATION PAGE** — READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: N-1594-ONR	2. GOVT ACCESSION NO.: AD-A096243	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): 6 Planning During Map Learning: The Global Strategies of High and Low Visual-Spatial Individuals.		5. TYPE OF REPORT & PERIOD COVERED: 9 Interim rept.
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): 10 Cathleen/Stasz		8. CONTRACT OR GRANT NUMBER(s): 15 N00014-78-C-0042
9. PERFORMING ORGANIZATION NAME AND ADDRESS: The Rand Corporation, 1700 Main Street, Santa Monica, CA 90406		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Personnel and Training Research Programs, Office of Naval Research (Code 458), Arlington, VA 22217		12. REPORT DATE: 11 Dec[redacted]80
		13. NUMBER OF PAGES: 33
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): 12 51		15. SECURITY CLASS. (of this report): Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

No Restrictions

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Maps	Learning
Memory (Psychology)	Problem Solving
Visual Perception	Perception
Verbal Behavior	Behavioral Science

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

See Reverse Side

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

296600 gn

A RAND NOTE

PLANNING DURING MAP LEARNING:
THE GLOBAL STRATEGIES OF HIGH
AND LOW VISUAL-SPATIAL INDIVIDUALS

Cathleen Stasz

December 1980

N-1594-ONR

Prepared For The Office of Naval Research

Rand
SANTA MONICA, CA. 90406

PREFACE

This study is the third and last in a series of Rand investigations of the process of map learning. This Note supplements findings previously reported in Stasz and Thorndyke (1980) and Stasz (1980). Rand's map-learning research has been supported by the Personnel and Training Research Programs of the Office of Naval Research, under Contract No. N00014-78-C-0042.

SUMMARY

This Note investigates the relationship between people's visual-spatial ability and their global strategies for learning maps. The results are based on experiments in which 25 subjects differing in spatial restructuring and visual memory abilities provided verbal protocols while attempting to learn maps. These protocols suggested a number of strategies that subjects used to approach the learning problem. Three strategies structured the learning task of successful map learners by providing algorithms for systematically focusing attention on various subsets of map information. Unsuccessful map learners adopted other or no strategies. Subjects high in visual-spatial ability tended to adopt these attention-focusing strategies, while most low-ability subjects used no systematic strategy.

ACKNOWLEDGMENTS

This study is a portion of the author's doctoral dissertation submitted to the University of California, Los Angeles. Conversations with Richard J. Shavelson and Morton P. Friedman contributed to the research reported here. The contributions of Perry Thorndyke, whose collaboration made this research possible and who provided helpful comments on an earlier draft of this Note, are also gratefully acknowledged. Finally, the Note greatly benefited from Richard J. Shavelson's thoughtful review.

CONTENTS

FIGURES

TABLES

I. INTRODUCTION

The learning of a body of information frequently depends on strategies that the learner uses during study. The term strategy refers here to the individual's general approach to the task or overall plan for proceeding. The notion of a strategy or a plan of action is fundamental to the view of learning as an active, intentional process carried out by the learner (Bower, 1975). Researchers have studied strategies for performance on a variety of tasks, including concept learning (Bruner, Goodnow, & Austin, 1956; Johnson, 1978); learning a zoological taxonomy (Pask & Scott, 1972); solving verbal, numerical, and geometrical analogies (Heller, 1979; Corsale & Gitomer, 1979; Mulholland, Pellegrino, & Glaser, 1980); mental arithmetic (Dansereau, 1969); sequence extrapolation (Greeno & Simon, 1974); and the Tower of Hanoi puzzle (Simon, 1975). Much of this research treats strategies as comprising particular combinations and sequences of low-level information processes, such as rehearsing an item in short-term memory or comparing an item in memory to the current stimulus. These lower-level processes, or procedures, may be automatic or learner-controlled (Hunt, 1978; Posner & Snyder, 1975).

Variations in subjects' use of strategies for a specific task are often attributed to ability differences (Cronbach & Snow, 1977). Abilities, as traditionally measured by psychometric tests, reflect stable, individual traits that influence performance skill on tasks requiring the measured ability (Fleishman, 1967). MacLeod, Hunt, and Matthews (1978), for example, found that subjects with high spatial ability used a pictorial-spatial strategy on a sentence-picture verification task, while lower-ability subjects adopted a linguistic strategy. Frederiksen (1969) found that subjects with different verbal abilities (e.g., associative memory, associative fluency) employed different strategies when learning word lists. Furthermore, many subjects' strategies were not well suited to the task conditions. Finally, individuals differing in field-independence, a cognitive style construct representing restructuring ability (Witkin & Goodenough, 1977), have exhibited strategy differences on a variety of tasks. For example, field-independent individuals adopt an active, hypothesis-testing strategy in concept-attainment tasks (Nebelkopf & Dreyer, 1973) and utilize category clustering in verbal free recall tasks (Meshorer, 1969). In contrast, field-dependent individuals adopt a more passive, spectator role in concept learning by waiting for evidence to accumulate over learning trials before attempting to identify any concept. All of these studies indicate that while ability differences may influence strategy choice, the chosen strategy does not always improve learning.

This Note examines the strategies individuals use to learn geographic maps. The research examines the relationship between map-learning expertise and learner strategies, and the relationship between these strategies and abilities. Our previous studies of map learning (Thorndyke & Stasz, 1980; Stasz & Thorndyke, 1980) have identified 16 procedures that subjects may use to focus attention, encode information, and evaluate their learning progress while studying a map.

Imagery, for example, is an encoding procedure used to memorize configurations of spatial information. In these earlier studies, each individual's unique study style was defined by the subset of the procedures he or she employed.

To compare procedure use with map-learning skill, we determined the proportion of elements correctly reproduced (both spatial location and verbal label correctly specified) on maps subjects drew after each study trial. We found that "good" learners--subjects recalling at least 90 per cent of the map elements--used a certain subset of the procedures more frequently than poor learners (Thorndyke & Stasz, 1980; Stasz & Thorndyke, 1980). Furthermore, the validity of these procedures as underlying map learning was tested in an experiment. Individuals who were taught to use these "effective" procedures significantly improved their map learning over uninstructed individuals and individuals taught to use other, less effective procedures.

Several findings have also suggested that good and poor map learners differ in basic abilities (Stasz & Thorndyke, 1980; Thorndyke & Stasz, 1980). First, subjects' informal reports of their visual imagery ability correlated with their choice of learning procedures and their success on the learning task. Second, poor learners were inaccurate in their evaluations of what they had already learned (Thorndyke & Stasz, 1980; Stasz & Thorndyke, 1980). One possible explanation for this latter finding is that the evaluation procedure may have required subjects to visualize a portion of the learned map and compare it to information on the printed map. Thus, subjects' visual abilities might also underlie their skill at using this procedure (and perhaps others).

Third, when subjects were trained to use six effective learning procedures, high-visual-ability subjects improved tremendously after training, while low-ability subjects improved no more than subjects uninstructed in these procedures. Thus, the success of instruction in using procedures also depended on visual abilities. Finally, pre-selected groups of subjects with high and low visual-spatial ability differed in their use of imagery for encoding spatial information and in their subsequent recall of spatial information on the map. In addition, data on abilities were better predictors of learning performance than data on procedure usage.

Since abilities appear to influence subjects' selection of and success at executing relatively low-level learning procedures, they may influence other aspects of study behavior as well. In particular, abilities may influence subjects' selection of an overall approach to a learning problem (i.e., their global strategy). Such a strategy is a critical component of the map-learning task, since all of the information to be learned is presented simultaneously rather than sequentially. Subjects must decide for themselves what information to learn first and how much time to spend studying each portion of the map. Thus, individuals with spatial restructuring skill may adopt strategies that subdivide the learning task into smaller subtasks. For example, subjects may use a divide-and conquer strategy to partition the map into a set of meaningful regions. They could then focus attention on and learn one region before moving on to learn another region. In a previous study, the best map learner seemed to adopt this type of strategy. In contrast, subjects with low spatial restructuring ability may be simply overwhelmed by the visual complexity of the stimulus and may study the map haphazardly. The present study focuses on the identification of global learning strategies and their relationship to abilities and performance on the map-learning task.

In the present study, we collected data on subjects' spatial and verbal abilities and observed their study procedures and strategies on map-learning tasks to determine what strategies people of varying abilities use, which procedures are associated with each strategy, and whether strategy use can predict learning rate. Using subjects' ability scores, we also examined whether their abilities influenced their choice of strategies.

II. METHOD

SUBJECTS

Twenty-five subjects were selected from an initial group of 94 UCLA undergraduates, on the basis of performance on a battery of standard psychometric ability tests. The tests measured visual memory, general intelligence, verbal associative memory, and field-independence (Witkin & Goodenough, 1977). For a description of these tests, see Stasz and Thorndyke (1980). The 25 subjects comprised two groups: one scoring high on field-independence and visual memory tests, and the other scoring low on these tests. The two groups had equivalent scores on the tests of general intelligence and verbal associative memory, and no subject differed by more than one standard deviation from the overall sample mean on each of these tests.

PROCEDURE

Subjects were individually tested in the map-learning task. Subjects alternately studied and reproduced two maps. One of these, a map of an imaginary town, is shown in Fig. 1. The other map portrayed an imaginary continent with countries, cities, roads, railroads, rivers, and mountains.

On each trial, subjects studied the map for two minutes and then drew from memory what they could recall from the map. While they studied, subjects verbalized their study behavior, including what they were looking at and the procedures and strategies they were using to learn

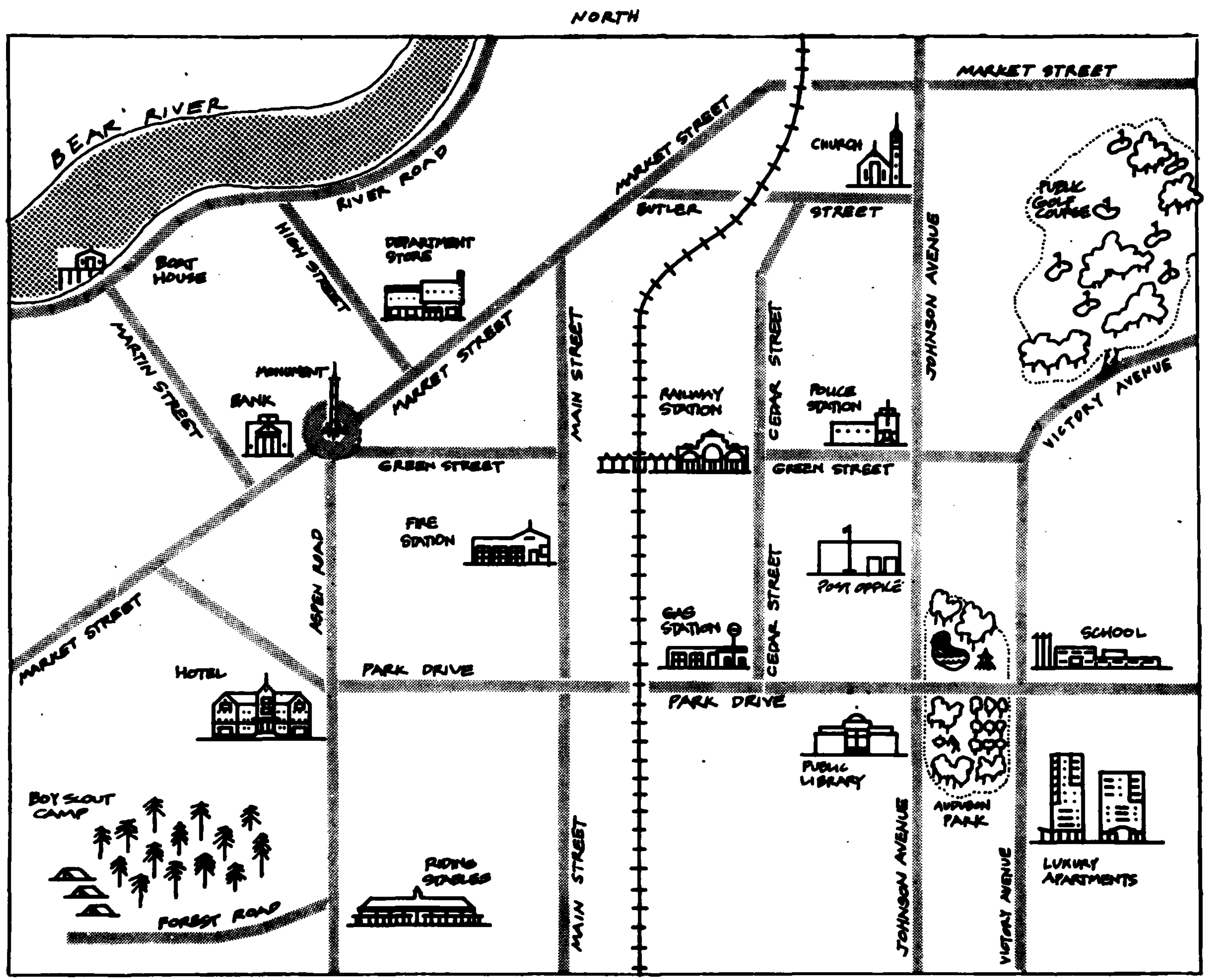


Fig. 1--The town map

the map. After six study-recall trials (or fewer if the subject learned the map perfectly), subjects answered eight location and route-finding questions from memory. For example, subjects studying the town map were asked, "What is the shortest route from the hotel to the police station?" Finally, subjects were interviewed about their learning techniques and approaches. They were asked to describe their overall strategy for learning each map and to provide any additional information about the learning task, such as level of difficulty.

PROTOCOL SCORING

To score the protocols, we defined the subjects' task-related statements and sorted them into previously identified and operationalized procedures (Thorndyke & Stasz, 1980; Stasz & Thorndyke, 1980). Table 1 list the procedures that are important for characterizing the different learning strategies discussed below.[1] This scoring method yielded, for each subject, the frequency of occurrence of each procedure on each of the study trials.

MAP SCORING

Subjects' reproduced maps were scored for accuracy according to the methods detailed in Thorndyke and Stasz (1980). Briefly, each element on the map has two potential attributes: a verbal label and a spatial location. The scoring method yielded three separate scores for each trial: percent of verbal attributes correctly recalled, percent of

---

[1] Readers interested in the other procedures used for map learning should see Thorndyke and Stasz (1980), or Stasz and Thorndyke (1980).

Table 1

SOME OF THE PROCEDURES USED DURING MAP LEARNING

Name	Function
Spatial partitioning	Define a spatial region of the map
Conceptual partitioning	Define a category of map elements (e.g., roads)
Random sampling	Select successive elements for study randomly
Stochastic sampling	Select for study an element adjacent to the current one
Systematic sampling	Move in a consistent direction to select successive elements
Association	Define a semantic relationship among two or more elements
Evaluation	Decide whether or not the current element has been learned
Planning	Decide on high-level strategy or plan of action for the approaching task

spatial attributes correctly recalled, and percent of total elements recalled (both verbal and spatial elements correct).

III. RESULTS

Data analyses addressed four questions about the global strategies subjects used during study: (1) What strategies do people use to learn maps? (2) What procedures do various strategies require? (3) Do strategies improve learning? (4) Do subjects with different abilities use different strategies?

IDENTIFICATION OF LEARNING STRATEGIES

The study protocols indicated that subjects differed widely in their approach to learning. Some learners adopted a specific strategy and articulated their approach during study. Other subjects with a seemingly systematic approach did not make strategy statements during study but did explain their general strategy in post-experiment interviews. The remainder of the subjects neither articulated a learning strategy nor demonstrated a consistent approach to learning the map information.

Potential strategies which subjects might use were identified in a number of ways. For example, a subject in a previous experiment adopted a "divide-and-conquer" strategy by defining a subset of the map information (e.g., streets) and focusing on elements in that set until all the elements were learned (Thorndyke & Stasz, 1980). Other potential strategies came from the problem-solving literature. Finally, some subjects made general planning statements, which were coded as instances of the planning procedure. Stasz and Thorndyke (1980) found that good learners more frequently stated an overall plan for learning the map than poorer learners.

With these potential strategies in mind, we reviewed each protocol and sorted them into seemingly similar strategy types. Three types of data aided this categorization process: strategy statements appearing in the protocols (i.e., instances of the planning procedure); strategy statements made in post-experiment interviews; and contents of the reproduced maps. Map reproductions served primarily as verifications that subjects were learning according to their stated strategies.

Across all subjects, four general strategies emerged: the "divide and conquer" (DC) strategy, the "global network" (GN) strategy, the "progressive expansion" (PE) strategy, and the "narrative elaboration" (NE) strategy. These strategies are described below.

Divide-and-Conquer Strategy. Subjects using the DC strategy sought to divide the map into smaller, more manageable regions for study. They first used the partitioning procedure to spatially subdivide the map into several sections. As illustrated in Fig. 2, subjects focused their attention on a single area, such as the northwest corner of the map, ignoring information outside of that area. They then adopted a variety of procedures to learn the information in the identified area. Having satisfied themselves that they had learned this information, they then moved on to study a new region. This process continued until all sections of the map had been studied. Thus, they treated each section of the map as a separate sub-problem. The following excerpt from a protocol illustrates how one subject articulated this strategy on his first study trial on the town map.

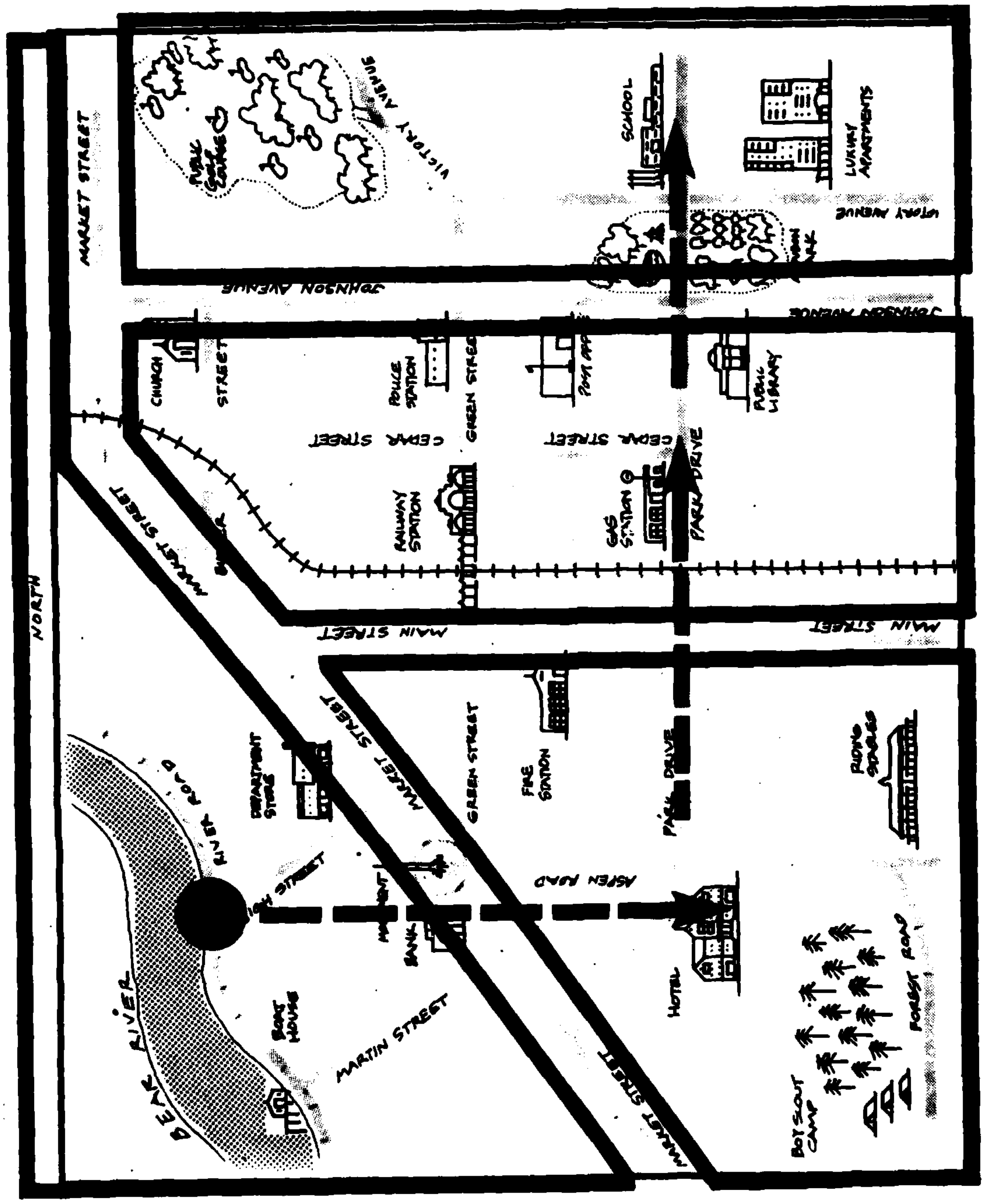


Fig. 2—Divide-and-conquer (DC) strategy

> "Okay. First thing is see is I'm ... going to divide the town into five major areas by streets. I notice Market Street running northeast and southwest, about two-thirds of the way and then straightening out and running east and west. And then I'm going to take Main Street and Johnson Avenue as two more major areas that I can look at. That's just ... four areas instead of five. Look at each of those as one separate area. Start up here ... north of Market Street and the Bear River ..."

This subject continued to study the first specified area, using a variety of study procedures, throughout trial 1. Midway into trial 2, he said, "So I'm going to try now to look at what's between Market Street and Main Street." Thus, he switched his attention to the second region he identified. Similar statements indicated regional switches on trials 3 and 4. This subject used the final trials to review each area independently and to integrate the separate areas to maintain feature continuity.

Global Network Strategy. Subjects using the GN strategy first identified a small set of salient features or a type of feature that could provide a spatial framework covering the entire area of the map. These subjects learned the names and locations of these reference points and then learned new elements by relating them to the location of the reference points. They thus developed a network of spatial relations anchored by the initial global framework. Rather than focusing initially on particular geographical areas, as with the DC strategy, these subjects established their initial framework by focusing, for example, on a certain conceptual category of information (such as streets, cities, or particular terrain features) or on a few large, salient map features.

An illustration of this strategy is provided by a subject who initially focused on four large features: the river, the railroad track, the boy scout camp and the golf course:

> "The first time I look at the geographical features, like the river, ... there's a railroad right down the middle, there's a golf course right here in the corner, a boy scout camp over here..."

After studying the four large features distributed across the map, this subject noted new element locations relative to these main features on subsequent trials. In effect, the initial elements became starting points for stochastically sampling new information. Stochastic sampling involved shifting the focus of attention from the current element to an adjacent element, but in no systematic or consistent direction. The sequence of foci seems to describe a "random walk" (Feller, 1966) through the map. This sampling procedure is illustrated in Fig. 3. The arrows point to adjacent elements that the subject may choose to sample. Solid arrows indicate actual choices, while broken arrows denote adjacent elements not sampled from that particular starting point.

<u>Progressive</u> <u>Expansion</u> <u>Strategy</u>. The third major strategy, PE, is characterized by subjects' systematic movement of attention across the map. Typically, subjects chose a starting point, such as the right side of the map in Fig. 4, and systematically moved across the map in a slow progression and in a consistent direction. When they encountered a new element, they studied it to learn its name and location. The following excerpt illustrates the PE strategy:

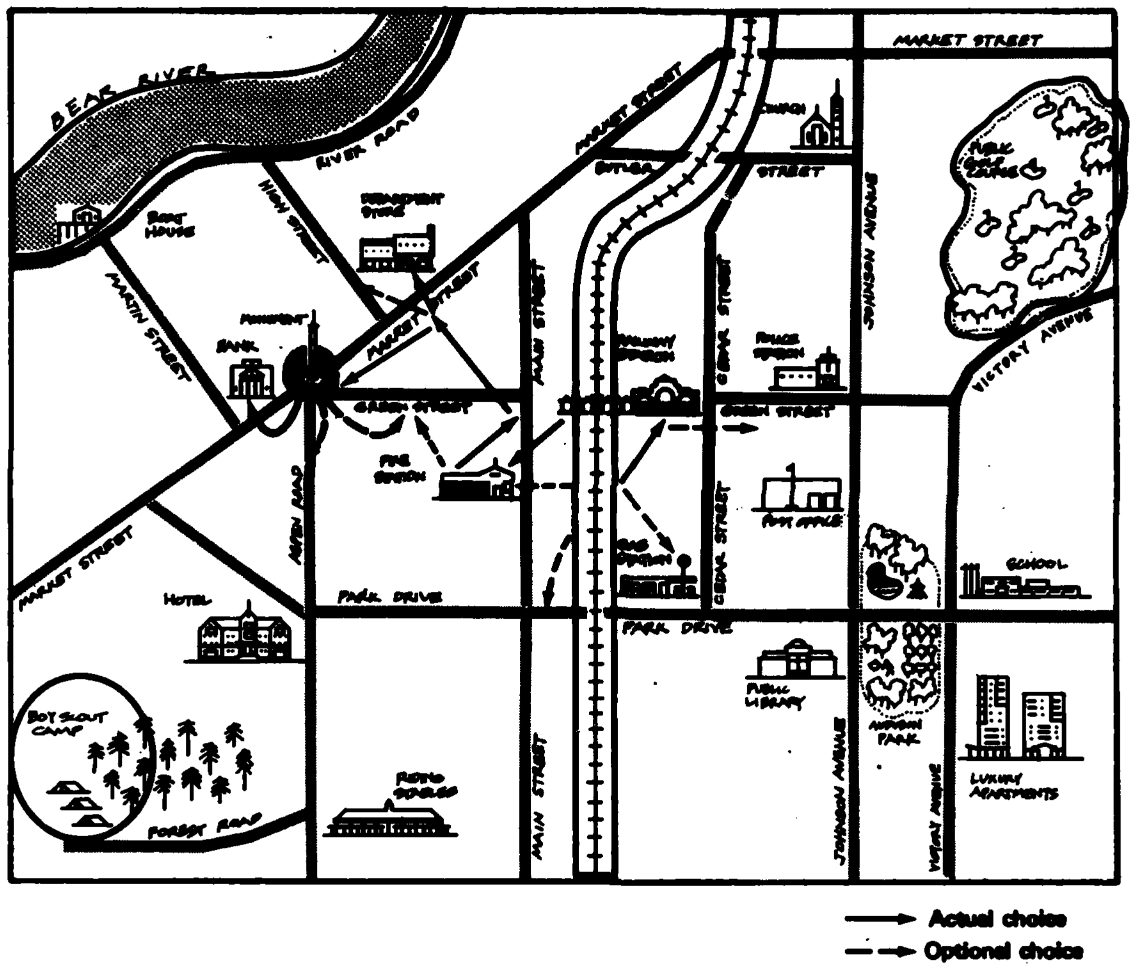


Fig.. 3--Global network (GN) strategy

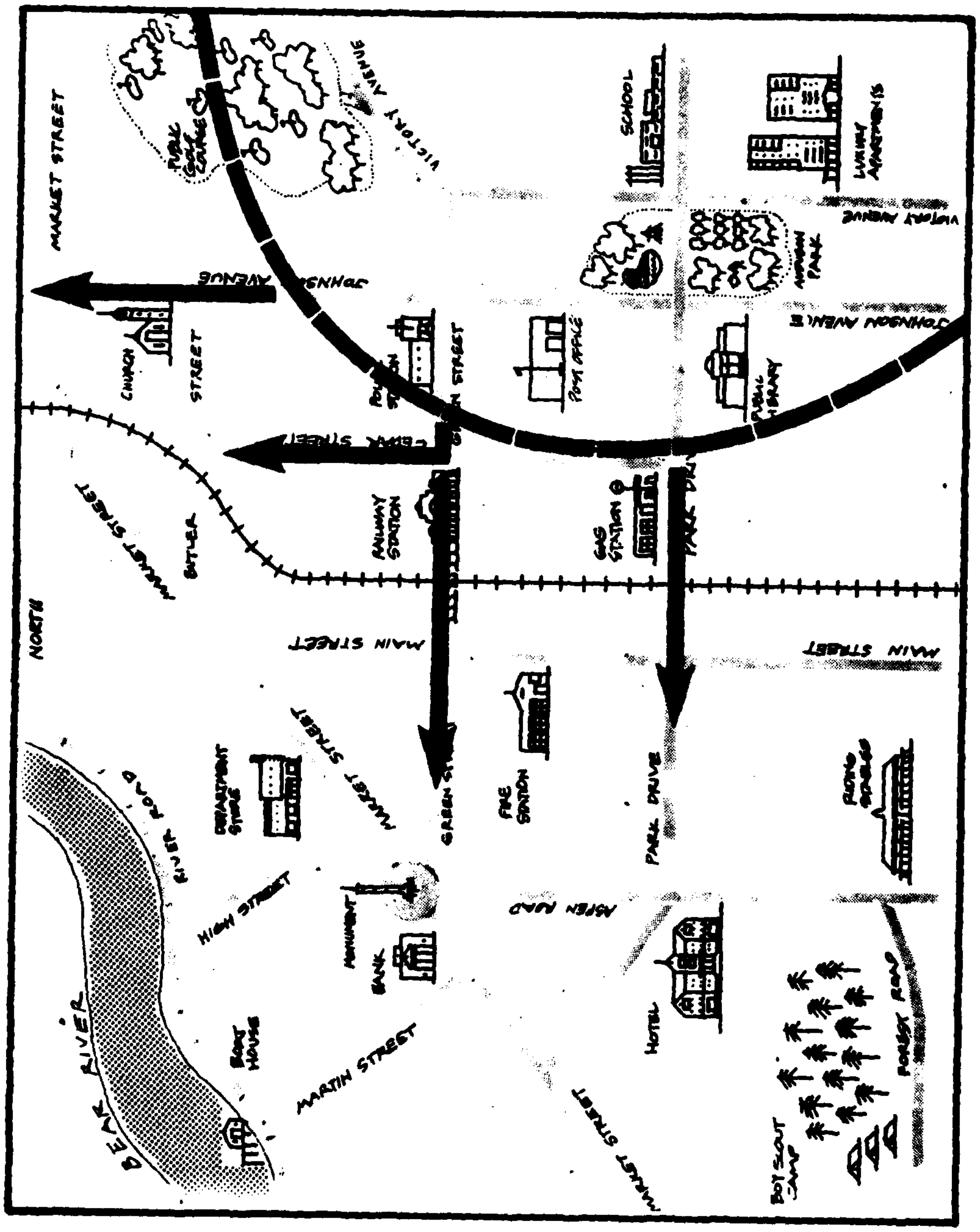


Fig. 4—Progressive expansion (PE) strategy

> "I look over the whole thing. Okay. I guess I'll start at one corner, get one little section. I'll start at the right hand corner. Okay. From Green street down." [The subject studies the right side for 2 trials, and in the middle of trial 3 says,] "Okay. Then the next thing after Cedar Street is the railway...then Main Street."

This subject systematically moved across the map from right to left. This progression was clearly reflected in her map reproductions. Elements on the lower right-hand side of the map, south of Green Street, appeared on the first map reproduction, but the left-hand side of the page was blank. Her trial 2 map reproduction included all streets and buildings east of Cedar Street, but no elements west of the railroad track.

Narrative Elaboration Strategy. While the DC, GN, and PE strategies rely on specific attention-focusing procedures, the NE strategy does not. Subjects using the NE strategy attempted to learn the map by creating narratives or categories incorporating adjacent elements. This required the elaboration of verbal attributes by association to or embellishment with some related prior knowledge. Thus, NE strategists learned the configuration of map elements by inventing verbal chains or associations whose ordered set of element names implied spatial relations. For example, one subject noted the cluster of "tree" streets that included Aspen Road, Forest Road, and Park Drive. This subject also generated and rehearsed the following narrative: "Martin went to the river after the market, came back high, and then went to the department store." Thus, he created an association among Martin Street, the river, Market Street, High Street, and the department store (see Fig. 5). This subject primarily used such association procedures to learn both maps (31 percent of all procedure invocations were of this type).

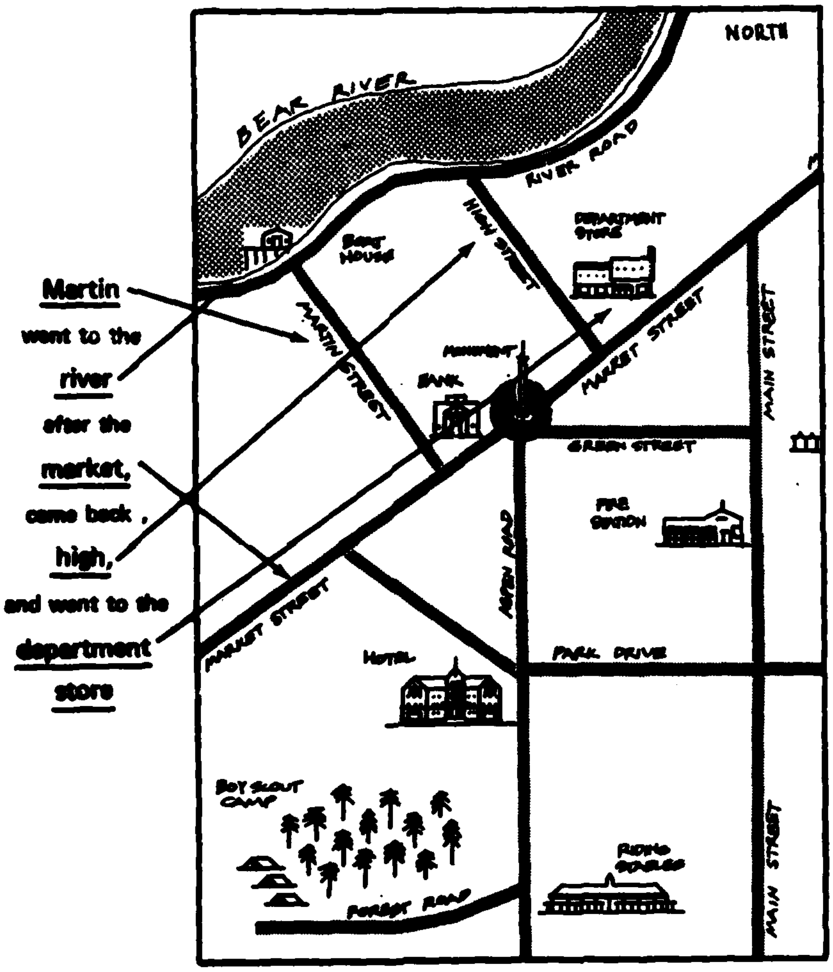


Fig. 5--Narrative elaboration (NE) strategy

One investigator sorted the subjects into groups, based on the strategies they used to learn the maps. A second investigator then sorted a random subset of the protocols. The raters agreed in 90 percent of the cases. The 50 sets of study protocols (two maps for each of 25 subjects) were sorted into five categories: the four strategies described above--DC (N = 7), GN (N = 12), PE (N = 11), NE (N = 2)--and no apparent strategy (N = 17). One subject used a strategy that seemed idiosyncratic to the countries map, and the resulting protocol could not be unambiguously categorized; therefore, we eliminated it from the analysis.

Most subjects consistently used the same strategy for both maps. This was true for three out of four subjects in the DC group, five out of seven subjects in the GN group, five out of six subjects in the PE group, and the single NE subject. Of the remaining subjects, one switched strategies from one map to the next and two adopted a strategy only for the second map.

THE RELATIONSHIP BETWEEN STRATEGIES AND PROCEDURES

Each of the four strategies we have identified suggests the use of certain study procedures. The DC, GN, and PE strategies all require subjects to structure the learning task by adopting some attention-focusing plan. These strategies seem to differ primarily in the particular type of attention-focusing procedures they prescribe. Subjects using the DC strategy, for example, must employ a spatial partitioning procedure to divide the areas into geographic regions. Having selected a region for study, subjects may use systematic or stochastic sampling to switch their attention among the various elements in the designated region. On the other hand, GN strategists, would be more likely to use conceptual partitioning to establish their initial framework. From each reference point in that framework, subjects would sample elements stochastically. For example, the GN strategist illustrated in Fig. 3 began with the railroad track and sampled elements in the following order: railway station, fire station, Main Street, Market Street, monument, and bank. The PE strategists would use the partitioning procedures less frequently than DC or GN strategists. Since the PE strategy entails systematic movement of the focus of attention across the map, subjects using this strategy would frequently use the systematic sampling procedure. By contrast, the NE strategy requires frequent use of the association procedure but does not entail the use of a particular attention-focusing procedure. Thus, each of these four strategies depends on the use of certain procedures. We sought confirmation for these procedural invocations in the DC, GN, PE, and NE strategies to demonstrate their distinctive characters.

We compared procedures used by subjects in each strategy group. Table 2 presents the mean number of occurrences of five procedures in the protocols of subjects using the various strategies. In computing these means, a subject's score for each procedure was the total number of occurrences of the procedure across the six study trials.

Differences between strategy means on each procedure were tested using the Kruskal-Wallis one-way analysis of variance (Siegel, 1956). Since use of the attention-focusing procedures was of interest primarily to distinguish among the DC, GN, and PE strategies, the analyses for the partitioning and sampling procedures included only these three groups.

As expected, subjects using different strategies varied in their use of attention-focusing procedures. Significant differences were found for the spatial partitioning ($H = 9.74$, $p < .001$), stochastic sampling ($H = 16.51$, $p < .001$), and systematic sampling procedures ($H = 17.57$, $p < .001$). To determine which between-group means were significantly different, we computed Mann-Whitney U-tests with an alpha level of .05 (Siegel, 1956). The DC strategists spatially partitioned the map more frequently than subjects in the other groups. In contrast, the GN strategists used conceptual partitioning and stochastic sampling more

Table 2

MEAN FREQUENCY OF OCCURRENCE OF LEARNING PROCEDURES IN PROTOCOLS DEMONSTRATING VARIOUS GLOBAL STUDY STRATEGIES

	Strategy				
Procedures	DC	GN	PE	NE	No Strategy
Spatial partitioning	2.71	0.17	1.00	0.00	0.47
Conceptual partitioning	2.00	2.67	1.09	0.00	0.71
Systematic sampling	3.00	0.58	3.36	0.00	1.18
Stochastic sampling	3.57	5.58	2.54	6.00	4.18
Association	5.14	6.00	11.00	22.00	1.70

frequently than the DC and PE strategists. Subjects in the PE strategy group employed the systematic sampling procedure more frequently than the GN and DC strategists, although only the difference between the first pair of strategies was statistically significant. Subjects in the NE and No-Strategy groups used partitioning and systematic sampling much less frequently than subjects in the other groups, if at all.

To test group differences in the use of the association procedure, we computed a Kruskal-Wallace one-way analysis of variance which included the DC, GN, PE, and NE strategy groups. However, this test revealed that the observed differences were not significant. The fact that the NE group contained only two protocols probably contributed to the failure to obtain significance. It is possible that this strategy is idiosyncratic to one individual, at least for the map-learning problem. However, researchers in verbal learning cite many instances of what we have called the association procedure and have advocated this technique for learning verbal information (e.g., Bower & Clark, 1969; Wittrock, 1974).

These results suggest that the DC, GN, and PE strategies may be differentiated by the frequency with which their prescribed procedures are invoked. Subjects do appear to implement their learning plan in accordance with the general approach suggested by the global strategy they adopt.

THE RELATIONSHIP BETWEEN STRATEGIES AND PERFORMANCE

Since the map information is presented simultaneously and not sequentially, learners must make decisions and take actions to control the content order of information they study. Thus, it is reasonable to suppose that the adoption of a global strategy is an important part of learning. If so, then subjects who report attention-focusing strategies should be better map learners than subjects who do not. To test this prediction, we compared mean recall scores averaged across trials for subjects using the different strategies. Separate means were computed for recall of complete map elements, spatial attributes, and verbal attributes (see Table 3). Recall of complete map elements and spatial attributes was about 20 percent higher for subjects using the DC, GN, and PE strategies than for subjects using the NE or no strategy. Mean recall of verbal attributes was less variable across groups. Kruskal-Wallis one-way analyses of variance indicated significant differences for each dependent variable ($H = 38.99$, $p < .001$, for complete elements; $H = 36.74$, $p < .001$, for spatial attributes; $H = 16.02$, $p < .01$, for

Table 3

MEAN PERFORMANCE FOR SUBJECTS USING VARIOUS GLOBAL STRATEGIES

(Mean percentage recalled per trial)

	Strategy				
Recall Item	DC	GN	PE	NE	No Strategy
Complete elements	60.7	65.3	61.5	39.0	45.2
Spatial attributes	63.7	71.2	64.2	42.0	49.1
Verbal attributes	79.0	76.9	74.8	76.5	70.6

verbal attributes). Pairwise post-hoc comparisons between means using the Mann-Whitney U-test revealed that recall of complete elements did not differ among the DC, GN, and PE groups, but each of these three groups had significantly higher recall than the NE and No-Strategy groups ($p < .01$). The latter two groups did not differ from each other. Recall of spatial attributes produced the identical pattern of results. For recall of verbal attributes, both the DC and GN groups had significantly higher recall than the No-Strategy group ($p < .05$). Thus, subjects adopting any attention-focusing strategy recalled more complete elements and spatial attributes of the map than the NE strategist or the subjects with no apparent strategy. These results replicate our earlier findings (Thorndyke & Stasz, 1980) that individual differences in map learning depend primarily on the individual's skill at acquiring spatial information rather than on differences in the acquisition of verbal information.

ABILITY DIFFERENCES AND STRATEGY USAGE

To determine the relationships between ability and map recall, we analyzed differences in strategies and learning outcomes between extreme ability groups. Since subjects' performance on tests of field-independence and visual memory were highly correlated ($r = .66$, $p < .01$), most subjects fell into one of two extreme groups: relatively field-independent, high visual memory (HIGHS, N = 10) and field-dependent, low visual memory (LOWS, N = 10).

Stasz and Thorndyke's (1980) analysis of the performance of these groups indicated that HIGHS recalled significantly more complete elements and spatial attributes than LOWS. However, the groups did not differ in recall of verbal attributes. These results, coupled with the findings reported above, suggest that HIGHS may adopt attention-focusing strategies more frequently than LOWS. This hypothesis is supported by studies that show that in learning situations field-independent individuals typically adopt active learning approaches, while field-dependent individuals assume a more passive, spectator role (Goodenough, 1976).

To examine strategy differences in the HIGH and LOW ability groups, we sorted the 40 sets of protocols from the 20 subjects into one of the four strategy groups or into the No Strategy group. Table 4 shows that 80 percent of the HIGH subjects' protocols exhibited one of the three attention-focusing strategies. None of the HIGHS used the NE strategy. In contrast, 50 percent of the LOWS subjects' protocols contained no

Table 4

NUMBER OF PROTOCOLS FROM HIGH- AND LOW-ABILITY SUBJECTS INCORPORATING THE VARIOUS GLOBAL STRATEGIES

	Ability Group	
Strategy	HIGHS	LOWS
DC	2	3
GN	10	1
PE	4	4
NE	0	2
No strategy	4	10

consistent strategy and 10 percent exhibited the NE strategy. To test whether HIGHS and LOWS differed in their use of attention-focusing strategies and the use of no strategy, Fisher's exact test was computed separately for each map. Both tests indicated that the probability of chance differences at least this large in the tendency of the two groups to use a strategy is .08. Therefore, we conclude that these between-group differences are reliable.

IV. DISCUSSION

The analyses performed in this study suggest that both abilities and subject-selected strategies are important sources of individual differences in map learning. We identified four strategies that subjects used in the map-learning problem. Three of these--DC, GN, and PE--are characterized by the use of certain procedures for focusing attention on subsets of the map information. The fourth, NE, is characterized by extensive use of the association procedure, a technique for building relationships among multiple elements on the map.

Analyses of procedure use for each identified strategy indicated that the three attention-focusing strategies can be differentiated reasonably well by the frequency with which subjects use the particular procedures that instantiate them. The NE strategy, however, may be idiosyncratic to the single subject who used it for learning the maps. The fact that different strategies can be characterized by the use of particular procedures is a measure of validity for the proposed strategy distinctions. This demonstration is one of several tests proposed by Johnson (1978) for validating concept-learning strategies. Another test is the consistency with which subjects employ the same strategy over repetitions of the task. This consistency was demonstrated for most of the subjects.

Analyses of strategy use and performance indicated that subjects employing attention-focusing strategies recalled more complete elements and spatial attributes of the map than other subjects. Further, subjects with high visual-spatial ability were more likely to use the attention-focusing strategies than low-ability subjects. This suggests that visual-spatial abilities may underlie the adoption of these strategies, and it supports the notion that learners can choose strategies that match their skills. However, we cannot assess from these data the relative importance of abilities and strategies for predicting learning success.

These results raise the important question of whether strategy training--particularly strategies for focusing attention--might improve map-learning performance. Given the nature of the map-learning task, the success of subjects who use attention-focusing strategies is not surprising. Moreover, focus of attention seems to be an important determinant of successful learning in other situations. Many studies in educational psychology have attempted to direct the attention of subjects when they are reading or learning from instruction. These instructional treatments have included, for example, adjunct questions inserted into a test or lesson (e.g., Boker, 1974; Felker & Dapra, 1975; Mayer, 1975, 1979; Sagaria & DiVesta, 1978) and providing objectives to learners either before or after they read a text (e.g., Kaplan & Simmons, 1974). Our research and these earlier studies suggest that attention-focusing strategies may facilitate knowledge acquisition across many content domains, and that teaching such strategies would be beneficial to students.

However, our analyses of the relationship between abilities and strategies suggest that abilities may underly strategy differences. This raises the question of whether low-ability subjects can be taught to use these strategies. Thorndyke and Stasz (1980) found that subjects with low visual-memory ability showed little improvement in learning after being trained to use effective study procedures, while medium- and high-ability subjects benefited from this training. Two of the instructed procedures, spatial partitioning and conceptual partitioning, play an important role in the effective strategies identified in the current study. If subjects with low visual ability cannot successfully implement these procedures, it seems unlikely that they would be successful in using strategies that require these procedures. Thus, it appears that subsequent research on the trainability of general learning strategies must consider individual differences in learner abilities.

REFERENCES

Boker, J. R. Immediate and delayed retention effects of interspersing questions in written instructional passages. Journal of Educational Psychology, 1974, 66, 96-98.

Bower, G. H. & Clark, M. C. Narrative stories as mediators for serial learning. Psychonomic Science, 1969, 14, 181-182.

Bower, G. H. Cognitive psychology: An introduction. In W. K. Estes (ed.), Handbook of learning and cognitive processes, Vol. 1. Hillsdale, N.J.: Lawrence Erlbaum, 1975.

Bruner, J. S., Goodnow, J. J., & Austin, G. A. A study of thinking. New York: Wiley, 1956.

Corsale, K. & Gitomer, D. Developmental and individual differences in mathematical aptitude. Paper presented at the annual meeting of the Psychonomic Society, Phoenix, Arizona, 1979.

Cronbach, L. J. & Snow, R. E. Aptitudes and instructional methods: A handbook for research on interactions. New York: Irvington, 1977.

Dansereau, D. An information processing model of mental arithmetic. Unpublished doctoral dissertation, Carnegie-Mellon University, 1969.

Feller, D. B. & Dapra, R. A. Effects of question type and question placement on problem-solving ability from prose material. Journal of Educational Psychology, 1975, 67, 380-384.

Fleishman, E. A. Individual differences and motor learning. In R. M. Gagne (ed.), Learning and individual differences. Columbus, Ohio: Charles E. Merrill, 1967.

Frederiksen, C. H. Abilities, transfer, and information retrieval in verbal learning. Multivariate Behavioral Research Monographs, No. 69-2, 1969.

Goodenough, D. R. The role of individual differences in field dependence as a factor in learning and memory. Psychological Bulletin, 1976, 83, 675-694.

Greeno, J. G. & Simon, H. A. Processes for sequence production. Psychological Review, 1974, 81, 187-198.

Heller, J. T. Cognitive processing in verbal analogy solution. Unpublished doctoral dissertation, University of Pittsburgh, 1979.

Hunt, E. Mechanics of verbal ability. Psychological Review, 1978, 2, 109-130.

Johnson, E. S. Validation of concept-learning strategies. _Journal of Experimental Psychology_, 1978, _3_, 237-266.

Kaplan, R. & Simmons, F. G. Effects of instructional objectives used as orienting stimuli or as summary/review upon prose learning. _Journal of Educational Psychology_, 1974, _66_, 614-622.

Mayer, R. E. Different problem-solving competencies established in learning computer programming with and without meaningful models. _Journal of Educational Psychology_, 1975, _67_, 165-169.

Mayer, R. E. Can advance organizers influence meaningful learning? _Review of Educational Research_, 1979, _49_, 371-383.

MacLeod, C. M., Hunt, E., & Matthews, N. Individual differences in the verification of sentence-picture relationships. _Journal of Verbal Learning and Verbal Behavior_, 1978, _17_, 493-507.

Meshorer, D. P. Field approach and stress as factors in the organization of memory (doctoral dissertation, Florida State University, 1969). _Dissertation Abstracts International_, 1970, _31_, 1544B.

Mulholland, T. M., Pellegrino, J. W., & Glaser, R. Components of geometrical analogy solution. _Cognitive Psychology_, 1980, _12_, 252-284.

Nebelkopf, E. B. & Dreyer, A. S. Continuous-discontinuous concept attainment as a function of individual differences in cognitive style. _Perceptual and Motor Skills_, 1973, _36_, 655-662.

Newell, A., & Simon, H. A. _Human problem solving_. Englewood Cliffs, N. J.: Prentice-Hall, 1972.

Pask, G. & Scott, B.C.E. Learning strategies and individual competence. _International Journal of Man-Machine Studies_, 1972, _4_, 217-253.

Posner, M. I. & Snyder, C.R.R. Attention and cognitive control. In R. Solso (ed.), _Information Processing and Cognition: The Loyola Symposium_. Hillsdale, N.J.: Lawrence Erlbaum, 1975.

Sagaria, S. D. & DiVesta, F. J. Learner expectations induced by adjunct questions and the retrieval of intentional and incidental information. _Journal of Educational Psychology_, 1978, _70_, 280-288.

Siegel, S. _Non-parametric statistics for the behavioral sciences_. New York: McGraw-Hill, 1956.

Simon, H. A. The functional equivalence of problem-solving skills. _Cognitive Psychology_, 1975, _7_, 268-288.

Stasz, C. & Thorndyke, P. W. The influence of visual-spatial ability and study procedures on map learning skill. N-1501-ONR, The Rand Corporation, Santa Monica, California, 1980.

Thorndyke, P. W. & Stasz, C. Individual differences in procedures for knowledge acquisition from maps. Cognitive Psychology, 1980, 12, 137-175.

Witkin, H. A. & Goodenough, D. R., Field-dependence revisited. Research Bulletin 77-16, Princeton, N. J.: Educational Testing Service, 1977.

Wittrock, M. C. Learning as a generative process. Educational Psychologist, 1974, 11, 87-95.

Navy

1 Dr. Robert Blanchard
Navy Personnel R&D Center
Managment Support Department
San Diego, CA 92151

1 Dr. Robert Breaux
Code N-711
NAVTRAEQUIPCEN
Orlando, FL 32813

1 Chief of Naval Education and Training
Liason Office
Air Force Human Resource Laboratory
Flying Training Division
WILLIAMS AFB, AZ 85224

1 Dr. Richard Elster
Department of Administrative Sciences
Naval Postgraduate School
Monterey, CA 93940

1 DR. PAT FEDERICO
NAVY PERSONNEL R&D CENTER
SAN DIEGO, CA 92152

1 Dr. John Ford
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Henry M. Halff
Department of Psychology,C-009
University of California at San Diego
La Jolla, CA 92093

1 LT Steven D. Harris, MSC, USN
Code 6021
Naval Air Development Center
Warminster, Pennsylvania 18974

1 CDR Charles W. Hutchins
Naval Air Systems Command Hq
AIR-340F
Navy Department
Washington, DC 20361

Navy

1 CDR Robert S. Kennedy
Head, Human Performance Sciences
Naval Aerospace Medical Research Lab
Box 29407
New Orleans, LA 70189

1 Dr. Norman J. Kerr
Chief of Naval Technical Training
Naval Air Station Memphis (75)
Millington, TN 38054

1 Dr. William L. Maloy
Principal Civilian Advisor for
Education and Training
Naval Training Command, Code 00A
Pensacola, FL 32508

1 Dr. Kneale Marshall
Scientific Advisor to DCNO(MPT)
OP01T
Washington DC 20370

1 CAPT Richard L. Martin, USN
Prospective Commanding Officer
USS Carl Vinson (CVN-70)
Newport News Shipbuilding and Drydock Co
Newport News, VA 23607

1 Dr. George Moeller
Head, Human Factors Dept.
Naval Submarine Medical Research Lab
Groton, CN 06340

1 Dr William Montague
Navy Personnel R&D Center
San Diego, CA 92152

1 Naval Medical R&D Command
Code 44
National Naval Medical Center
Bethesda, MD 20014

1 Mr. William Nordbrock
Instructional Program Development
Bldg. 90
NET-PDCD
Great Lakes Naval Training Center,
IL 60088

Navy

1 Ted M. I. Yellen
Technical Information Office, Code 201
NAVY PERSONNEL R&D CENTER
SAN DIEGO, CA 92152

1 Library, Code P201L
Navy Personnel R&D Center
San Diego, CA 92152

1 Technical Director
Navy Personnel R&D Center
San Diego, CA 92152

6 Commanding Officer
Naval Research Laboratory
Code 2627
Washington, DC 20390

1 Psychologist
ONR Branch Office
Bldg 114, Section D
666 Summer Street
Boston, MA 02210

1 Psychologist
ONR Branch Office
536 S. Clark Street
Chicago, IL 60605

5 Personnel & Training Research Programs
(Code 458)
Office of Naval Research
Arlington, VA 22217

1 Psychologist
ONR Branch Office
1030 East Green Street
Pasadena, CA 91101

1 Office of the Chief of Naval Operations
Research Development & Studies Branch
(OP-115)
Washington, DC 20350

1 LT Frank C. Petho, MSC, USN (Ph.D)
Code L51
Naval Aerospace Medical Research Laborat
Pensacola, FL 32508

Navy

1 Dr. Gary Poock
Operations Research Department
Code 55PK
Naval Postgraduate School
Monterey, CA 93940

1 Roger W. Remington, Ph.D
Code L52
NAMRL
Pensacola, FL 32508

1 Mr. Arnold Rubenstein
Naval Personnel Support Technology
Naval Material Command (08T244)
Room 1044, Crystal Plaza #5
2221 Jefferson Davis Highway
Arlington, VA 20360

1 Dr. Worth Scanland
Chief of Naval Education and Training
Code N-5
NAS, Pensacola, FL 32508

1 Dr. Robert G. Smith
Office of Chief of Naval Operations
OP-987H
Washington, DC 20350

1 Dr. Alfred F. Smode
Training Analysis & Evaluation Group
(TAEG)
Dept. of the Navy
Orlando, FL 32813

1 Dr. Richard Sorensen
Navy Personnel R&D Center
San Diego, CA 92152

1 Dr. Robert Wisher
Code 309
Navy Personnel R&D Center
San Diego, CA 92152

Army

1 HQ USAREUE & 7th Army
ODCSOPS
USAAREUE Director of GED
APO New York 09403

1 DR. RALPH DUSEK
U.S. ARMY RESEARCH INSTITUTE
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333

1 DR. FRANK J. HARRIS
U.S. ARMY RESEARCH INSTITUTE
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333

1 Col Frank Hart
Army Research Institute for the
Behavioral & Social Sciences
5001 Eisenhower Blvd.
Alexandria, VA 22333

1 Dr. Michael Kaplan
U.S. ARMY RESEARCH INSTITUTE
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333

1 Dr. Milton S. Katz
Training Technical Area
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Director
U.S. Army Human Engineering Labs
Attn: DRXHE-DB
Aberdeen Proving Ground, MD 21005

1 Dr. Harold F. O'Neil, Jr.
Attn: PERI-OK
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

1 Dr. Robert Sasmor
U. S. Army Research Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Army

1 Dr. Joseph Ward
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Air Force

1 Air University Library
AUL/LSE 76/443
Maxwell AFB, AL 36112

1 Dr. Earl A. Alluisi
HQ, AFHRL (AFSC)
Brooks AFB, TX 78235

1 Dr. Genevieve Haddad
Program Manager
Life Sciences Directorate
AFOSR
Bolling AFB, DC 20332

1 Dr. Ross L. Morgan (AFHRL/LR)
Wright -Patterson AFB
Ohio 45433

1 Dr. Marty Rockway (AFHRL/TT)
Lowry AFB
Colorado 80230

2 3700 TCHTW/TTGH Stop 32
Sheppard AFB, TX 76311

1 Jack A. Thorpe, Maj., USAF
Naval War College
Providence, RI 02846

Marines

1 H. William Greenup
Education Advisor (E031)
Education Center, MCDEC
Quantico, VA 22134

1 Major Howard Langdon
Headquarters, Marine Corps
OTTI 31
Arlington Annex
Columbia Pike at Arlington Ridge Rd.
Arlington, VA 20380

1 Special Assistant for Marine
Corps Matters
Code 100M
Office of Naval Research
800 N. Quincy St.
Arlington, VA 22217

1 DR. A.L. SLAFKOSKY
SCIENTIFIC ADVISOR (CODE RD-1)
HQ, U.S. MARINE CORPS
WASHINGTON, DC 20380

Other DoD

12 Defense Technical Information Center
Cameron Station, Bldg 5
Alexandria, VA 22314
Attn: TC

1 Dr. Craig I. Fields
Advanced Research Projects Agency
1400 Wilson Blvd.
Arlington, VA 22209

1 Dr. Dexter Fletcher
ADVANCED RESEARCH PROJECTS AGENCY
1400 WILSON BLVD.
ARLINGTON, VA 22209

1 Cdr. Van K. Nield, USN
Code STT
Headquarters, Defense Mapping Agency
Building 56
Naval Observatory
Washington, DC 20305

1 Military Assistant for Training and
Personnel Technology
Office of the Under Secretary of Defense
for Research & Engineering
Room 3D129, The Pentagon
Washington, DC 20301

Civil Govt

1 Dr. Susan Chipman
Learning and Development
National Institute of Education
1200 19th Street NW
Washington, DC 20208

1 Dr. Joseph I. Lipson
SEDR W-638
National Science Foundation
Washington, DC 20550

1 Dr. John Mays
National Institute of Education
1200 19th Street NW
Washington, DC 20208

1 Dr. Arthur Melmed
National Intitute of Education
1200 19th Street NW
Washington, DC 20208

1 Dr. Andrew R. Molnar
Science Education Dev.
and Research
National Science Foundation
Washington, DC 20550

1 Dr. Joseph L. Young, Director
Memory & Cognitive Processes
National Science Foundation
Washington, DC 20550

Non Govt

1 Dr. John R. Anderson
Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213

1 DR. MICHAEL ATWOOD
SCIENCE APPLICATIONS INSTITUTE
40 DENVER TECH. CENTER WEST
7935 E. PRENTICE AVENUE
ENGLEWOOD, CO 80110

1 1 psychological research unit
Dept. of Defense (Army Office)
Campbell Park Offices
Canberra ACT 2600, Australia

1 Dr. Alan Baddeley
Medical Research Council
Applied Psychology Unit
15 Chaucer Road
Cambridge CB2 2EF
ENGLAND

1 Dr. Patricia Baggett
Department of Psychology
University of Denver
University Park
Denver, CO 80208

1 Dr. Nicholas A. Bond
Dept. of Psychology
Sacramento State College
600 Jay Street
Sacramento, CA 95819

1 Dr. Lyle Bourne
Department of Psychology
University of Colorado
Boulder, CO 80309

1 Dr. John S. Brown
XEROX Palo Alto Research Center
3333 Coyote Road
Palo Alto, CA 94304

1 Dr. Bruce Buchanan
Department of Computer Science
Stanford University
Stanford, CA 94305

Non Govt

1 Dr. Pat Carpenter
Department of Psychology
Carnegie-Mellon University
Pittsburgh, PA 15213

1 Dr. John B. Carroll
Psychometric Lab
Univ. of No. Carolina
Davie Hall 013A
Chapel Hill, NC 27514

1 Charles Myers Library
Livingstone House
Livingstone Road
Stratford
London E15 2LJ
ENGLAND

1 Dr. William Chase
Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213

1 Dr. Micheline Chi
Learning R & D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

1 Dr. Kenneth E. Clark
College of Arts & Sciences
University of Rochester
River Campus Station
Rochester, NY 14627

1 Dr. Allan M. Collins
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, Ma 02138

1 Dr. Lynn A. Cooper
Department of psychology
Uris Hall
Cornell University
Ithaca, NY 14850

Non Govt

1 Dr. Meredith P. Crawford
American Psychological Association
1200 17th Street, N.W.
Washington, DC 20036

1 Dr. Kenneth B. Cross
Anacapa Sciences, Inc.
P.O. Drawer Q
Santa Barbara, CA 93102

1 Dr. Hubert Dreyfus
Department of Philosophy
University of California
Berkely, CA 94720

1 LCOL J. C. Eggenberger
DIRECTORATE OF PERSONNEL APPLIED RESEARC
NATIONAL DEFENCE HQ
101 COLONEL BY DRIVE
OTTAWA, CANADA K1A 0K2

1 Dr. Victor Fields
Dept. of Psychology
Montgomery College
Rockville, MD 20850

1 Dr. Edwin A. Fleishman
Advanced Research Resources Organ.
Suite 900
4330 East West Highway
Washington, DC 20014

1 DR. JOHN D. FOLLEY JR.
APPLIED SCIENCES ASSOCIATES INC
VALENCIA, PA 16059

1 Dr. John R. Frederiksen
Bolt Beranek & Newman
50 Moulton Street
Cambridge, MA 02138

1 Dr. Alinda Friedman
Department of Psychology
University of Alberta
Edmonton, Alberta
CANADA T6G 2E9

Non Govt

1 Dr. R. Edward Geiselman
Department of Psychology
University of California
Los Angeles, CA 90024

1 DR. ROBERT GLASER
LRDC
UNIVERSITY OF PITTSBURGH
3939 O'HARA STREET
PITTSBURGH, PA 15213

1 Dr. Marvin D. Glock
217 Stone Hall
Cornell University
Ithaca, NY 14853

1 DR. JAMES G. GREENO
LRDC
UNIVERSITY OF PITTSBURGH
3939 O'HARA STREET
PITTSBURGH, PA 15213

1 Dr. Harold Hawkins
Department of Psychology
University of Oregon
Eugene OR 97403

1 Dr. Barbara Hayes-Roth
The Rand Corporation
1700 Main Street
Santa Monica, CA 90406

1 Mr. Richards J. Heuer, Jr.
27585 Via Sereno
Carmel, CA 92923

1 Dr. James R. Hoffman
Department of Psychology
University of Delaware
Newark, DE 19711

1 Dr. Lloyd Humphreys
Department of Psychology
University of Illinois
Champaign, IL 61820

Non Govt

1 Dr. Earl Hunt
Dept. of Psychology
University of Washington
Seattle, WA 98105

1 DR. KAY INABA
21116 VANOWEN ST
CANOGA PARK, CA 91303

1 DR. LAWRENCE B. JOHNSON
LAWRENCE JOHNSON & ASSOC., INC.
Suite 103
4545 42nd Street, N.W.
Washington, DC 20016

1 Dr. Steven W. Keele
Dept. of Psychology
University of Oregon
Eugene, OR 97403

1 Dr. Walter Kintsch
Department of Psychology
University of Colorado
Boulder, CO 80302

1 Dr. David Kieras
Department of Psychology
University of Arizona
Tuscon, AZ 85721

1 Dr. Kenneth A. Klivington
Program Officer
Alfred P. Sloan Foundation
630 Fifth Avenue
New York, NY 10111

1 Dr. Stephen Kosslyn
Harvard University
Department of Psychology
33 Kirkland Street
Cambridge, MA 02138

1 Mr. Marlin Kroger
1117 Via Goleta
Palos Verdes Estates, CA 90274

Non Govt

1 Dr. Jill Larkin
Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213

1 Dr. Alan Lesgold
Learning R&D Center
University of Pittsburgh
Pittsburgh, PA 15260

1 Dr. Robert A. Levit
Director, Behavioral Sciences
The BDM Corporation
7915 Jones Branch Drive
McClean, VA 22101

1 Dr. Charles Lewis
Faculteit Sociale Wetenschappen
Rijksuniversiteit Groningen
Oude Boteringestraat
Groningen
NETHERLANDS

1 Dr. Allen Munro
Behavioral Technology Laboratories
1845 Elena Ave., Fourth Floor
Redondo Beach, CA 90277

1 Dr. Donald A Norman
Dept. of Psychology C-009
Univ. of California, San Diego
La Jolla, CA 92093

1 Dr. Jesse Orlansky
Institute for Defense Analyses
400 Army Navy Drive
Arlington, VA 22202

1 MR. LUIGI PETRULLO
2431 N. EDGEWOOD STREET
ARLINGTON, VA 22207

1 Dr. Martha Polson
Department of Psychology
University of Colorado
Boulder, CO 80302

Non Govt

1 DR. PETER POLSON
DEPT. OF PSYCHOLOGY
UNIVERSITY OF COLORADO
BOULDER, CO 80309

1 DR. DIANE M. RAMSEY-KLEE
R-K RESEARCH & SYSTEM DESIGN
3947 RIDGEMONT DRIVE
MALIBU, CA 90265

1 Dr. Fred Reif
SESAME
c/o Physics Department
University of California
Berkely, CA 94720

1 Dr. Andrew M. Rose
American Institutes for Research
1055 Thomas Jefferson St. NW
Washington, DC 20007

1 Dr. Ernst Z. Rothkopf
Bell Laboratories
600 Mountain Avenue
Murray Hill, NJ 07974

1 Dr. David Rumelhart
Center for Human Information Processing
Univ. of California, San Diego
La Jolla, CA 92093

1 DR. WALTER SCHNEIDER
DEPT. OF PSYCHOLOGY
UNIVERSITY OF ILLINOIS
CHAMPAIGN, IL 61820

1 Dr. Alan Schoenfeld
Department of Mathematics
Hamilton College
Clinton, NY 13323

1 DR. ROBERT J. SEIDEL
INSTRUCTIONAL TECHNOLOGY GROUP
HUMRRO
300 N. WASHINGTON ST.
ALEXANDRIA, VA 22314

Non Govt

1 Dr. Robert Smith
Department of Computer Science
Rutgers University
New Brunswick, NJ 08903

1 Dr. Richard Snow
School of Education
Stanford University
Stanford, CA 94305

1 Dr. Robert Sternberg
Dept. of Psychology
Yale University
Box 11A, Yale Station
New Haven, CT 06520

1 DR. ALBERT STEVENS
BOLT BERANEK & NEWMAN, INC.
50 MOULTON STREET
CAMBRIDGE, MA 02138

1 Dr. David Stone
ED 236
SUNY, Albany
Albany, NY 12222

1 DR. PATRICK SUPPES
INSTITUTE FOR MATHEMATICAL STUDIES IN
THE SOCIAL SCIENCES
STANFORD UNIVERSITY
STANFORD, CA 94305

1 Dr. Douglas Towne
Univ. of So. California
Behavioral Technology Labs
1845 S. Elena Ave.
Redondo Beach, CA 90277

1 Dr. J. Uhlaner
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

1 Dr. Benton J. Underwood
Dept. of Psychology
Northwestern University
Evanston, IL 60201

Non Govt

1 Dr. David J. Weiss
N660 Elliott Hall
University of Minnesota
75 E. River Road
Minneapolis, MN 55455

1 Dr. Keith T. Wescourt
Information Sciences Dept.
The Rand Corporation
1700 Main St.
Santa Monica, CA 90406

1 Dr. Christopher Wickens
Department of Psychology
University of Illinois
Champaign, IL 61820

1 Dr. J. Arthur Woodward
Department of Psychology
University of California

4